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KARLA IRINA WALSH GARCIA

CONCENTRAÇÃO DE FLUORETO NO SAL COMERCIALIZADO EM MANÁGUA, NICARÁGUA

FLUORIDE CONCENTRATION IN SALT MARKETED IN MANAGUA, NICARAGUA

PIRACICABA

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Dissertação apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do título de Mestra em Odontologia, na Área de Cariologia

Dissertation presented to the Piracicaba Dental School, University of Campinas in partial fulfillment of the requirements for the degree of Master in Dentistry, in Cariology area

Orientador: Prof. Dr. Jaime Aparecido Cury

Este exemplar corresponde à versão final da dissertação defendida pela aluna Karla Irina Walsh Garcia e orientada pelo Prof. Dr Jaime Aparecido Cury.

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RESUMO

A fluoretação do sal para consumo humano na Nicarágua é regulamentada por lei e a concentração de fluoreto deve estar entre 200 e 225 mg F/kg. Como não há relatos da concentração de fluoreto nos sais comercializados neste país, este estudo avaliou se os sais para consumo humano comercializados em Manágua, Nicarágua estavam sendo adequadamente fluoretados. A concentração de fluoreto de 33 pacotes de 11 marcas de sal (n=3) comercializados em Manágua foi determinada. De acordo com as informações da embalagem, nove sais eram produzidos localmente e dois importados da Costa Rica. Das 11 marcas de sal, em nove delas havia declaração que eram fluoretadas. Seis alíquotas de cada pacote foram pesadas (2,5 g ± 0,3; n=198) e dissolvidas na proporção de 0,025 g/ml de agua purificada. Duplicatas de 1,0 ml das soluções preparadas foram tamponadas (1:1; v/v) com TISAB II. A concentração de fluoreto foi determinada com eletrodo específico pelo método direto, o qual foi calibrado com soluções padrões (0,25 a 16,0 µg F/ml) preparados em TISAB II a 50% e contendo 0,0125 g de NaCl/ml. Das nove marcas declaradas como fluoretadas, duas apresentaram concentração (mg F/kg) de fluoreto (média ± dp; n=3) de acordo com a legislação nicaraguense (209,8 ± 48,0 e 211,4 ± 26,0), em cinco a concentração foi inferior (131,0 ± 34,3; 180,6 ± 12,3; 184,6 ± 34,8; 190,0 ± 47,2; 199,0 ± 18,9) e nas outras duas foram encontrados apenas traços de fluoreto. As duas marcas não fluoretadas continham traços de fluoreto. Os resultados mostram que a vigilância do programa de fluoretação do sal na Nicarágua precisa ser melhorada porque a concentração de fluoreto encontrada na maioria dos sais não está de acordo com a legislação local.

Palavras chaves: Fluoretação, Cloreto de sódio, Cárie dental, Eletrodos Íon-Seletivos, Vigilância sanitária

ABSTRACT

Fluoridation of salt for human consumption in Nicaragua is regulated by legislation and the fluoride concentration should be from 200 to 225 mg F/kg. Since there are no reports about the fluoride concentration in the salts marketed in this country, the aim of this study was to evaluate whether salts for human consumption marketed in Managua, Nicaragua were being properly fluoridated. It was determined the fluoride concentration in 33 packages of 11 salt brands (n=3) purchased in Managua city. According to the information on the packaging 9 brands were produced locally and two were imported from Costa Rica. Within the 11 salt brands, nine of them were declared as fluoridated. Six aliquots of each package were weighed (2.5 g ± 0.3; n=198) and dissolved in the proportion of 0.025 g/ml of purified water. Duplicates of 1.0 ml of the solutions prepared were buffered (1:1; v/v) with TISAB II. Fluoride concentration was determined with specific electrode by the direct method, that were calibrated with standard solutions (0.25 to 16.0 µg/ml) prepared in TISAB II at 50% and containing 0.0125 g NaCl/ml. Among the nine fluoridated brands, two presented a fluoride (mg/kg) concentration (mean ± SD; n=3) according to the Nicaraguan legislation (209.8 ± 48.0, 211.4 ± 26.0), five were below (131.0 ± 34.3, 180.6 ± 12.3, 184.6 ± 34.8, 190 ± 47.2, 199.0 ± 18.9) and two contained only traces of fluoride. The two non-fluoridated brands presented traces of fluoride. The findings show that the surveillance system of the salt fluoridation program in Nicaragua should be improved because the fluoride concentration in most of the salts is not according to the local legislation.

Keywords: Fluoridation, Sodium Chloride, Dental caries, Ion-Selective Electrodes, Health surveillance

SUMÁRIO

1 INTRODUÇÃO

A cárie dentária continua sendo a doença crônica mais prevalente do mundo, afetando ao redor de 3 bilhões de pessoas (Kassebaum et al., 2015). O uso de fluoreto é considerado um método altamente efetivo para o controle da cárie (World Health Organization, 1994; Petersen, 2003; Jones et al., 2005). Entre as medidas de saúde pública de uso de fluoreto, as de uso comunitário (água e sal fluoretado) são consideradas as mais abrangentes, atingindo todas as classes sociais da população.

A água fluoretada tem sido reconhecida como uma das principais medidas de saúde pública para o controle da cárie e a eficácia e segurança do seu uso tem sido amplamente discutidas (McDonagh et al., 2000; Australian goverment, 2007; Iheozor-Ejiofor et al., 2015; Rugg-Gunn et al., 2016). Esta medida continua sendo importante para alguns países (Do e Spencer; 2015; Frazão e Narvai, 2017; Australian goverment, 2017). Porém, quando sua implementação não é possível por várias razões, a fluoretação do sal tem sido recomendada como uma alternativa (Petersen e Lennon, 2004).

Na América Latina, a implementação de programas de fluoretação do sal apresentou um considerável progresso a partir de 1986. Segundo Marthaler et al. (2011), Costa Rica, Jamaica, Colômbia, México e Uruguai têm programas de fluoretação do sal consolidados há mais de 20 anos e outros países como Peru, Belize, Bolívia, Cuba, República Dominicana, Equador, Venezuela, Guatemala, Honduras, El Salvador e Nicarágua têm programas mais recentes de fluoretação do sal.

Os programas de fluoretação da água e o sal têm vantagens e desvantagens. Uma das vantagens da fluoretação do sal em relação à fluoretação da água, seria a facilidade de vigilância do programa, pois em qualquer país o número de produtores de sal a serem monitorados é muito menor que o número de plantas de tratamento da água. Com o objetivo de garantir uma adequada dosagem de fluoreto em termos de benefícios/riscos, a Organização Pan-americana de Saúde (OPS) tem recomendado enfaticamente a necessidade do monitoramento da concentração de fluoreto nos sais comercializados na América Latina (Organización Panamericana de la Salud, 1998; Estupiñán-Day, 2005). Esse monitoramento é indispensável para que o programa de fluoretação do sal atinja o máximo de benefício anticarie com um risco mínimo de desenvolver fluorose dental. Porém, análises da concentração de flúor em

sais comercializados no México (Maupamé et al., 1995; Martínez-Mier et al., 2004; Hernández-Guerrero et al., 2008), Colômbia (Franco et al., 2003; Tovar e Castrillon, 2016), Peru (Sunohara, 2006; Cury et al., 2017), El Salvador (Girón et al., 2005) e Guatemala (Organización Panamericana de la Salud, 2015) tem mostrado que os valores encontrados não estão de acordo com as regulamentações desses países.

Assim, no México, resultados encontrados por Maupamé et al. (1995) sobre a concentração de fluoreto de 221 amostras de sais, sendo 76% delas fluoretadas, mostrou que apenas 1% estava de acordo com a legislação mexicana (200-250 mg F/kg), 97% estava abaixo do mínimo estabelecido e 2% acima da legislação. Em acréscimo, Hernández-Guerrero et al. (2008), revelaram que de 44 amostras de sais (88% declaradas como fluoretadas), apenas 3 amostras fluoretadas (7%) cumpriam com a regulamentação local. Martínez-Mier et al. (2004) mostraram que a concentração de fluoreto em 51% das amostras de sais fluoretadas analisadas em 2002 e 2003, estava de acordo com a legislação local, mas em 41% estava abaixo e em 8% acima do estabelecido pela legislação mexicana.

De acordo com a legislação colombiana, a concentração de fluoreto no sal deve estar entre 180 e 220 mg F/kg. Porém, num estudo feito em quatro cidades colombianas encontrou-se que apenas 25% das amostras de sal tinham valores de acordo com a regulamentação local (Franco et al., 2003). Um relato apresentado pelo Ministério de Saúde da Colômbia mostrou que 77% das amostras de sal analisadas durante o período de 2012-2014 apresentaram concentração de fluoreto de acordo com o estabelecido pela legislação local, 18% estavam abaixo e 5% acima do recomendado (Tovar e Castrillon, 2016).

Problemas com a fluoretação no sal também foram relatados no Peru. Sunohara (2006) analisou 10 marcas de sais peruanos, das quais uma marca era declarada como fluoretada. Os resultados mostraram que na única marca fluoretada a concentração de fluoreto (152 ppm F) estava abaixo da legislação (200-250 mg F/kg). Um estudo mais recente de Cury et al. (2017) sobre a concentração de fluoreto em 4 marcas de sais peruanos fluoretados adquiridos em 2013, revelou que 57% das amostras de sal continham concentração de fluoreto de acordo com a legislação e as demais apresentaram concentração menor que o mínimo recomendado.

Assim, problemas da fluoretação do sal em países da América do Norte (México) e América do Sul (Colômbia e Peru) têm sido descritos. Com relação a dados da fluoretação de sais comercializados na América Central, um estudo desenvolvido

em El Salvador mostrou que 81% das amostras de sal analisadas continham valores de fluoreto inferiores ao sugerido pela OMS (180-220 ppm) e o restante estava acima desse valor (Girón et al., 2005). Um relatório apresentado pela OPS sobre sais guatemaltecos fluoretados e não fluoretados revelou que apenas 2,5% das amostras analisadas no período 2014-2015 apresentaram concentração de fluoreto de acordo com o estabelecido pela legislação local (175 a 225 mg/kg), 46,2% estavam abaixo e em 51% o fluoreto não foi detectado (Organización Panamericana de la Salud, 2015).

Em relação a Nicarágua, está em vigência uma lei que obriga a adição de flúor ao sal para consumo humano (Nicaragua, 2008), cuja concentração deve ser de 200 a 225 mg F/kg de sal (Nicaragua, 2010). Entretanto, não há dados mostrando se todo sal comercializado na Nicarágua esteja sendo fluoretado e em que concentração. Neste contexto, o objetivo deste estudo foi avaliar se a concentração de fluoreto nos sais para consumo humano comercializados em Manágua, Nicarágua estava de acordo com as regulamentações locais.

2 ARTIGO: FLUORIDE CONCENTRATION IN SALT MARKETED IN MANAGUA, NICARAGUA*

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Declaration of interest

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ABSTRACT

The Nicaraguan legislation establishes that fluoride concentration in salt should be from 200 to 225 mg F/kg, but there are no reports about fluoride concentration in salts marketed in this country. We evaluated the fluoride concentration in 33 packages of 11 salt brands (n=3) purchased in Managua city. According to the package information, 9 of the 11 brands were fluoridated. Six aliquots of each package were weighed (2.5 g ± 0.3; n=198) and dissolved in the proportion of 0.025 g/ml of water. Duplicates of 1.0 ml of the solutions prepared were buffered (1:1; v/v) with TISAB II. Fluoride concentration was determined with specific electrode, calibrated with standards solutions (0.25 to 16.0 µg F/ml) that were mixed (1:1; v/v) with TISAB II added of 0.025 g (p.a) NaCl/ml. In two of the fluoridated brands the fluoride concentration (mean ± SD; n=3) was according to the Nicaraguan law (209.8 ± 48.0 and 211.4 ± 26.0 mg F/kg), five had fluoride concentration below the local regulation (131.0 ± 34.3; 180.6 ± 12.3; 184.6 ± 34.8; 190 ± 47.2; 199.0 ± 18.9 mg F/kg) and in two only traces of fluoride were found. The two non-fluoridated brands presented traces of fluoride. The findings show that the surveillance system of salt fluoridation program in Nicaragua should be improved because most of the salts of this sampling are not according to the local legislation.

Keywords: Fluoridation, Sodium Chloride, Dental caries, Ion-Selective Electrodes, Surveillance system

INTRODUCTION

Community-based methods of fluoride use such as water and salt fluoridation play an important role in the control of dental caries.[1] When the implementation of water fluoridation is not feasible, salt fluoridation is suggested as an alternative community approach.[2] In Latin America, the adoption of salt fluoridation programs showed an increased from 1986.[3]

An effective surveillance system is required as part of the salt fluoridation program to ensure the balance between the anticaries effect (benefits) and the minimum of dental fluorosis provoked (risks). Thus, the Pan American Health Organization has emphatically recommended the monitoring of the fluoride concentration in salts marketed in countries with salt fluoridation programs.[4] However, fluoride concentration in disagreement with the local legislations has been found in salt brands marketed in México, Colombia, Peru, El Salvador and Guatemala. [5–13]

In Nicaragua, a law that demands the fluoridation of salt for human consumption was approved in 2007[14] and the range of fluoride concentration established is from 200 to 225 mg F/kg.[15] Nevertheless, there are no reports about the fluoride concentration in salts marketed in this country. Therefore, the aim of this study was to evaluate if salts marketed in Managua, Nicaragua were being properly fluoridated.

MATERIAL AND METHODS

Salt sampling

This exploratory in vitro study, blind regarding the laboratorial analysis, evaluated the fluoride concentration in 11 salt brands found in three main supermarket chains and one popular market of Managua city. Three packages from each salt brand were purchased (n=3) in July of 2016, preferably one package of each brand in a different place. An extra package of each salt brand (Ax…Kx) was purchased and stored for further analysis. All salts were sold to use for cooking (fluoridated or non-fluoridated). Salts presented in small containers for table or for barbecue use were not included in the sampling. Each brand of salt and each package (1, 2, 3 and x) was

coded according to the place of purchase to allow blind analysis (Table 1).

Table 1. Salt brands and code of analysis according to the place where the salt packages 1, 2, 3 and the extra package (x) were purchased

		Place of purchase			
Salt brands	Code of analysis	La Unión supermarket	La Colonia supermarket	Pali supermarket	Roberto Huembes market
Atlántida gruesa	A	A_1, Ax	-	A_2, A_3	-
Sabemas	B	B_1, Bx	-	B_2, B_3	-
La Cocinera	C	-	C_1, C_2, C_3, Cx		-
Atlántida fina	D	D_1, Dx	D_2	D_3	-
Atlántida refinada	E	E_1, E_2, E_3, Ex	-	-	-
Sol	F	F_1, Fx	F_2, F_3	-	-
Suli	G	G_1, Gx	-	G_2, G_3	-
Solar	H	H_1, H_2, H_3, Hx	-	-	-
Blanca Nieves	I	-	I_1, I_2, I_3, Ix	-	-
Cali-Sal	J	-	-	-	J_1, J_2, J_3, Jx
Flipper	K	-	-	-	K_1, K_2, K_3, Kx

Information declared on the label of salt packages about producer, batch, validity, type of granulation, declaration of fluoride addition and fluoride concentration indicated are presented in Table 2.

Table 2. Salt brands, code of analysis, producer, batch, validity, type of granulation, declaration of fluoride addition, fluoride concentration indicated and ingredients declared on the label

Salt brands	Code of analysis	Producer	Batch	Validity	Type of granulation	Declaration of fluoride addition	Fluoride concentration indicated (mg F/kg)	Ingredients
Atlántida Gruesa	A	Cosermusalnic, R.L e Nicasal (Nicaragua)	n.d.	n.d.	Coarse	Yes	200-225	NaCl (97%), F, I, Potassium Ferrocyanide (10 mg/kg)
Sabemas	B	Nicasal (Nicaragua)	n.d.	n.d.	Refined	Yes	200-225	NaCl, KF, KIO_3, SiO_2
La Cocinera	C	Salnicsa (Nicaragua)	C_1, C_2, C_3: 0006	C_1, C_2, C_3: Dez/20	Fine	Yes	200-225	NaCl, KF, KIO_3
Atlántida fina	D	Cosermusalnic, R.L e Nicasal (Nicaragua)	n.d.	n.d.	Fine	Yes	200-225	NaCl (97%), F, I, Potassium Ferrocyanide (10 mg/kg)
Atlántida Refinada	E	Cosermusalnic, R.L e Nicasal (Nicaragua)	n.d.	n.d.	Refined	Yes	200-225	NaCl (99.5%), F, I, SiO_2 (max 2%)
Sol	F	Coonarprosal R.L (Costa Rica)	F_1: 0416 F_2: 0216 F_3: 1015	n.d.	Refined	Yes	200-225	NaCl, F, I
Suli	G	Nicasal (Nicaragua)	G_1: 0025 G_2: 0026 G_3: 0021	n.d.	Fine	Yes	n.d.	NaCl, KF, KIO_3, Potassium Ferrocyanide
Solar	H	Coonarprosal R.L (Costa Rica)	H_1: 0115 H_2: 0316 H_3: 0615	n.d.	Ground	Yes	200-225	NaCl, F, I
Blanca Nieves	I	Salnicsa (Nicaragua)	n.d.	I_1: Jul/17 I_2, I_3: Jul/20	Fine	Yes	200-225	NaCl, KF, KIO_3
Cali-Sal	J	Producer María Calderón	n.d.	n.d.	Fine	No	Non-fluoridated	NaCl (98%), I, Potassium Ferrocyanide
Flipper	K	Producer María Calderón	n.d.	n.d.	Coarse	No	Non-fluoridated	NaCl, I

* n.d.: not declared

Salt samples harvest and preparation for analysis

To facilitate the transport of the salt samples from the place where they were purchased (Nicaragua) to the laboratory of analysis (Brazil), plastic capped pre-weighed tubes (10 ml) were used. The salt of every package was individually placed in a round plastic container and homogenized with rotatory movements for 2 min using a soup spoon.[16] Six salt aliquots of approximately 2.5 g were harvested from the top of the container and individually transferred to the codified tubes.

The capped tubes with the samples of salt were weighed using a precision balance (± 0.1 mg) and the weight of the salt samples was calculated (2.5 g ± 0.3; n=198). The samples were dissolved in purified water in the proportion (w/v) of 0.025 g of salt/1.0 ml of water. Fluoride concentration in the salt solutions was determined with ion-specific electrode (ISE) by the direct method using a protocol, validated for fluoride analysis in salt.[13,16,17]. The analysis of fluoride was carried out within two months after the salt samples acquisition.

Fluoride analysis in salt using ISE by the direct method

The protocol used was previously validated because it was shown that the recovery of fluoride added to the salt is from 96-98%.[16, 17] Also, the analytical relevance to adjust the ionic strength of the fluoride standards with pure NaCl was confirmed.[13,16,17] Standard fluoride solutions ranging from 0.25 to 16.0 µg F/ml, mixed with TISAB II (1:1, v/v) added of 0.025 g NaCl/ml were used to calibrate the equipment (electrode Orion 96-09 coupled to an ion analyzer Orion Star A214, both from Thermo Scientific, Cambridge, MA, EUA) for analysis.

Linear regression between the logarithm of fluoride concentration of the standards solutions and the respective mV was calculated using Microsoft Excel software. The mathematical equation of regression was used to determine the fluoride concentration in salt solutions (See Figure 1). The fluoride concentration in salt was

calculated and expressed in mg F/kg. The average variation coefficients of the repeated analyses (duplicate) was of 1.8% (n=198).

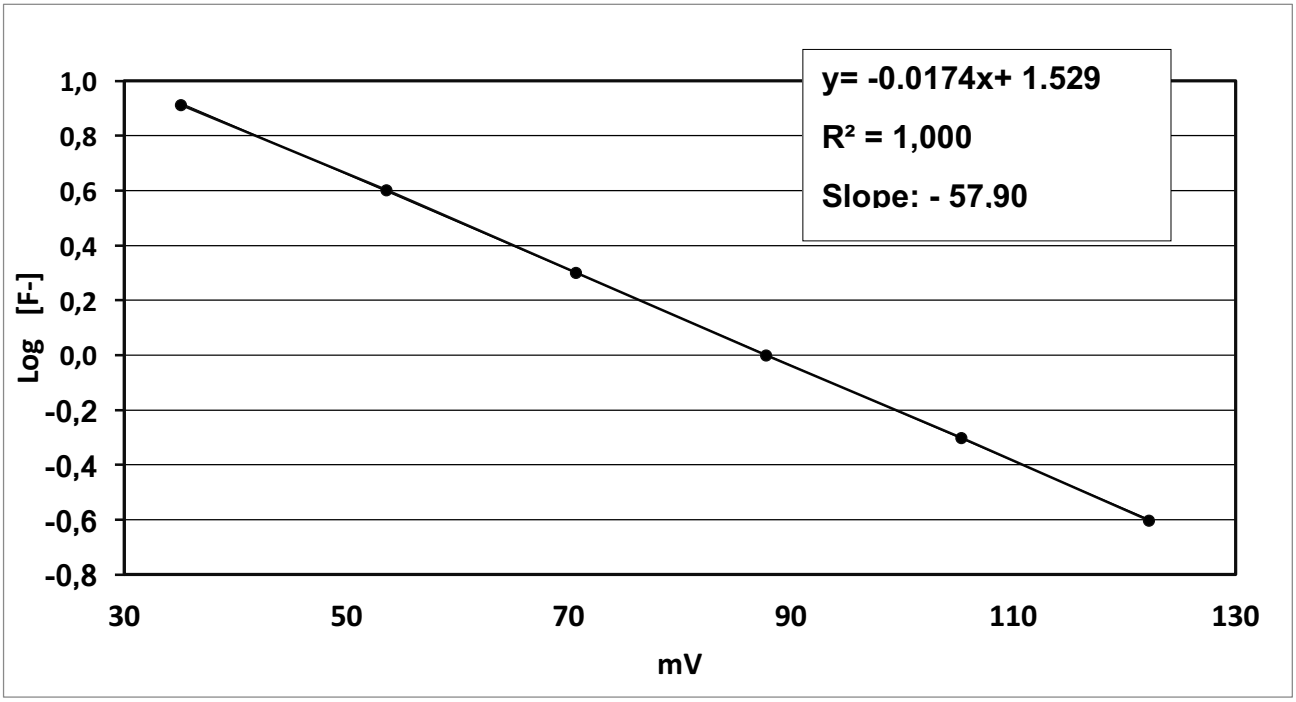

Fig 1. Calibration curve that correlates the logarithm of the fluoride concentration in standards and the relative mV generated (mean of 9)

Data analysis

Mean concentration of fluoride in the 6 aliquots of each salt package and the mean concentration of fluoride and standard deviation (SD) found in the 3 packages (n=3) were calculated with use of Microsoft Excel Software. Results were compared descriptively with the fluoride concentration established by the Nicaraguan regulation.

RESULTS

From the 11 salt brands purchased in Managua city, only one brand (code D) was found in three different places, four brands (codes A, B, F and G) in two places and six brands (codes C, E, H, I, J and K) were found in only one place (Table 1).

According to the label information, two salt brands were imported from Costa Rica (F and H) and the remaining were produced locally (Table 2). Moreover, two of the salts were non-fluoridated (codes J and K) and nine fluoridated (A, B, C, D, E, F, G, H and I). Among the fluoridated brands, eight (A, B, C, D, E, F, H and I) declared to contain from 200-225 mg F/kg, but in one (code G) the concentration was not declared. In four fluoridated brands the manufacturer declared to use potassium fluoride (KF) as the fluoride agent and in the remaining five, the fluoride agent was not disclosured.

As declared in the label, five (45.5%) of the brands were fine granulated, three (27.3%) refine granulated, two (18.2%) coarse granulated and one (9%) ground granulated (Table 2). The batch number was presented in only four brands (codes C, F, G and H). Among them, the packages of one brand (code C) were from the same batch, while in the others (codes F, G and H) the packages were from different batches.

Overall, the mean (±SD; n=3) of fluoride concentration found (mg F/kg) in the salt brands ranged from traces (<1.8) to 211.4 mg F/kg (Table 3). Among the fluoridated brands, two salts (code D and F) showed fluoride concentration according to the Nicaraguan legislation (209.8 ± 48 and 211.4 ± 26.0 respectively), five (codes A, E, B, G and H) had a fluoride concentration below the legislation (131.0 ± 34.3; 180.6 ± 12.3; 184.6 ± 34.8; 190.0 ± 47.2; 199.0 ± 18.9 respectively) and two (codes I and C) contained only traces of fluoride (fluoride concentration below the detection limit of ISE). Traces of fluoride were found in the two non-fluoridated brands (code K and J).

Table 3. Salt brands, code of analysis, fluoride concentration expected according to the label, mean (± SD; n= 3) of fluoride concentration and range (min-max) found (mg F/kg) in the samples of salt

Salt brands	Code of analysis	mg F/kg		
		*Expected (label)	Found	
			mean	(min-max)
Flipper	K	0	traces (< 3.2)	-
Cali sal	J	0	traces (< 3.3)	-
Blanca Nieves	I	200-250	traces (< 1.8)$^{\alpha}$	-
La Cocinera	C	200-250	traces (< 18.6)$^{\beta}$	-
Atlántida Gruesa	A	200-250	131.0 ± 34.3$^{\gamma}$	104.9 - 169.8
Atlántida Refinada	E	200-250	180.6 ± 12.3	168.4 - 191.6
Refinada Sabemas	B	200-250	184.6 ± 34.8	151.2 - 221.8
Suli	G	n.d.	190.0 ± 47.2	135.7 - 221.9
Solar	H	200-250	199.0 ± 18.9	186.3 - 219.0
Atlántida fina	D	200-250	209.8 ± 48.0	156.1 - 243.8
Sol	F	200-250	211.4 ± 26.0	190.3 - 240.4

* According to the legislation should be from 200-225 mg F/kg

$^{\alpha,\beta,\gamma}$ Concentration confirmed with ISE after microdiffusion (< 1.7, < 8 and 115.5 ± 14.2, respectively)

n.d.: not declared

DISCUSSION

Salt fluoridation has been widely implemented as a public health strategy to reduce dental caries,[2] but the monitoring of the fluoride concentration in salt is mandatory to guarantee the balance between benefits and risks of this way of fluoride use.[4] In Nicaragua, the salt fluoridation program is supported by law since 2007,[14] but there is no study about the fluoride concentration in salts marketed in this country. We believe that this is the first study that evaluated fluoride concentration in salts for human consumption marketed in Nicaragua.

As previously discussed,[17,18] to determine with precision and accuracy the fluoride concentration in salt it is necessary to use a valid methodology of analysis. Although we had used a validated method to evaluate fluoride concentration in the salt,[13,16,17] it has been reported that fluoride concentration in salt determined with ISE by the direct method could be underestimated from 67% to 90%.[18] Thus, we checked the results found for salts A, C and I (Table 2) by ISE after microdiffusion.[19] Therefore, the reliability of the analysis made with ISE by the direct method was confirmed because only traces of fluoride were found in salts C and I by both methodologies and salt A was in fact under-fluoridated (Table 3, footnote).

Also, the sampling of salt analyzed should be representative of the salts consumed in the country. Considering that Managua is the most populous and important city of Nicaragua and the salts were purchased in the main places of sale, we believe that the sampling included most of the salt brands used for cooking that were available in July 2016 in Nicaragua.

The findings of the present study show that the program of salt fluoridation in Nicaragua has problems to solve. The first one is the coverage of the program because according to the Nicaraguan legislation all salts for human consumption sold in the country should be fluoridated, but two of the 11 salt samples (J and K) analyzed were not being fluoridated (Table 3). Furthermore, according to the label salts brand C and I might be fluoridated (Table 3) but only traces of fluoride were found in the samples analyzed. In summary, from the total of 11 salt brands found in the market of Managua, 4 (36%) of them do not have any anticaries potential.

The other 64% (7/11) of salt brands (A, B, D, E, F, G and H) were being fluoridated but according to the Nicaraguan legislation, salt with fluoride concentration

below 200 would not guarantee the most beneficial anticaries effect for the consumer and those above 225 mg F/kg would provoke unacceptable dental fluorosis.[15] Table 3 shows that only 29% (2/7) of the fluoridated salt brands presented optimal fluoride concentration and the rest showed a mean fluoride concentration below the minimum recommended. Although the disagreement with the legislation, in most of these salts (except salt A) the low fluoride concentration found is not a concern regarding the anticaries effect because it is very close to the optimal. Moreover, the salt that presented a fluoride concentration considerably low (salt A) was coincidentally coarse granulated (Table 2). This finding could be because coarse salt particles have a proportionally smaller surface area than fine particles, thus affecting the final fluoride concentration.[4] However, in the salt code H, which was grounded, the fluoride concentration found was very close to the minimum expected.

Regarding the increased risk of dental fluorosis, there is no concern because none of the salt samples analyzed was over-fluoridated.

Besides the variability of fluoride concentration found between the salt brands analyzed, variability between the 3 packages for each brand was also found (Table 3). Considering the 7 salt brands that were being fluoridated (A, B, D, E, F, G and H), greater variability (SD) were observed in salts A, G, D and B than F, H and E. Considering that salt brands A, G, D and B are produced by the same manufacturer (Table 2), it is reasonable to think that the results reflects a poor-quality control of fluoride concentration during salt production.

The problems that we found with Nicaraguan salts have been reported in other countries where the program of fluoridated salt is implemented.[6–8,10-13] In El Salvador, 80% of 26 salt samples analyzed presented fluoride concentration below the minimum recommended.[11] In Guatemala, only 3% of the salt samples had fluoride values according to the legislation.[12] In México, only 1 and 7% of the salt samples analyzed in 1995[6] and 2008[7], respectively, were in agreement with the local legislation. In Colombian salt samples analyzed in 2003[8], only 25% of the samples had values established by local regulations. One study conducted in Peru in 2005[10], showed that only one from 10 peruvian salt was fluoridated but with concentration (152 ppm F) below the local legislation (200-250 mg F/kg). Recently, fluoridated Peruvian salt were analyzed and 57% of the samples contained fluoride concentration according to the legislation.[13]

In regards with the salt fluoridation program in Nicaragua, the impact in terms of benefits and risks is not known because there is no data about which salts are the most consumed by nicaraguans. It is reasonable to say that if most of the population consumed fluoridated salts and with optimal fluoride concentration or close to the optimal, the maximum anticaries benefits and lowest risk of fluorosis would be achieved. In contrast, if the salts most consumed by the population are non-fluoridated, the relevance of the salt fluoridation program would be reduced.

Another issue to discuss is that the established fluoride concentration in salt considered as “optimal” is based on the daily per capita consumption of salt in population. Moreover, it should be taken into account the variability of salt consumption within the country. In this regard, we could not find any data that shows how much is the daily salt consumption of nicaraguans.

In terms of public health, the findings are relevant not only to nicaraguan population because salt fluoridation programs are implemented worldwide. In Nicaragua, problems of different nature were found in the salt brands marketed with respect to fluoride concentration because was found in the sample analyzed: 1) Salt brands non- fluoridated 2) Salt brands declared as fluoridated but without fluoride addition and 3) Fluoridated salt brands presenting fluoride concentration below the minimal required. Nevertheless, salt brands with mean of fluoride concentration above the optimal range were not found.

CONCLUSION

The results suggest that the surveillance system of salt fluoridation program in Nicaragua should be improved because most of the salts of this sampling are not according to the local legislation.

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3 CONCLUSÃO

Os resultados dessa dissertação mostraram que há no mercado de Manágua, Nicarágua:

1. Marcas de sal não fluoretadas.
2. Marcas de sal que declararam serem fluoretadas, mas nas quais foram encontrados apenas traços de fluoreto.
3. Marcas de sal fluoretadas, mas contendo concentração inferior ao mínimo estabelecido pela legislação.

Assim, conclui-se que o sistema de vigilância governamental da Nicarágua não se mostra eficaz para garantir que toda a população receba sal adequadamente fluoretado.

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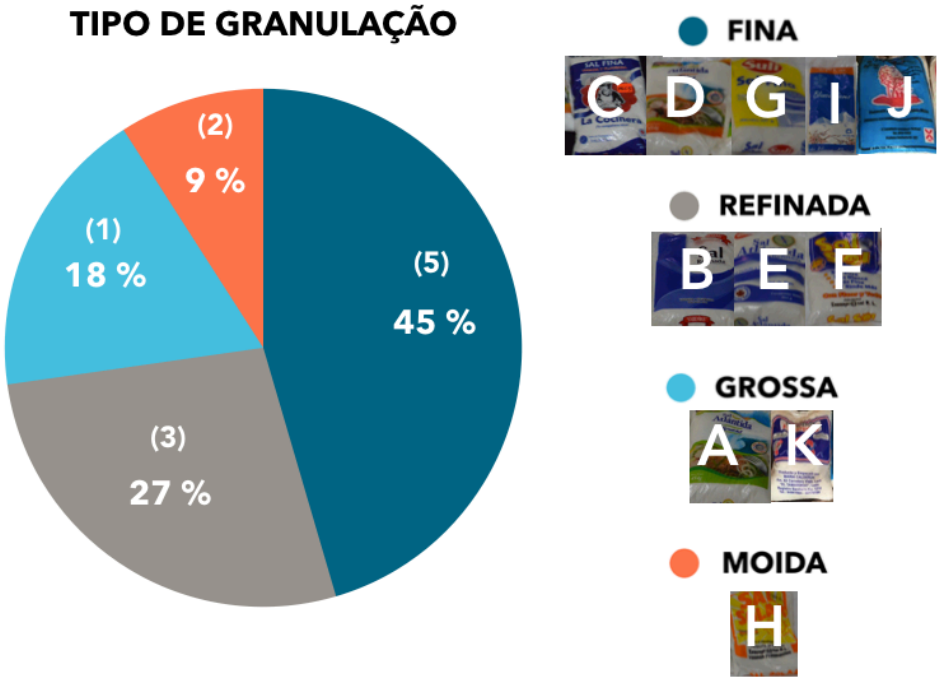
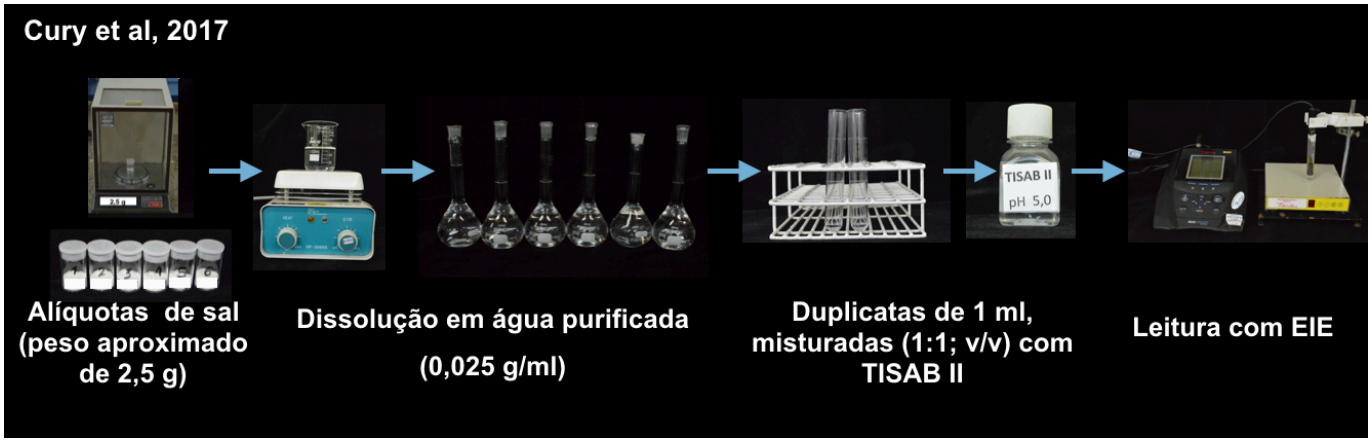
APÊNDICES

Apêndice 1. Marcas de sal analisadas.

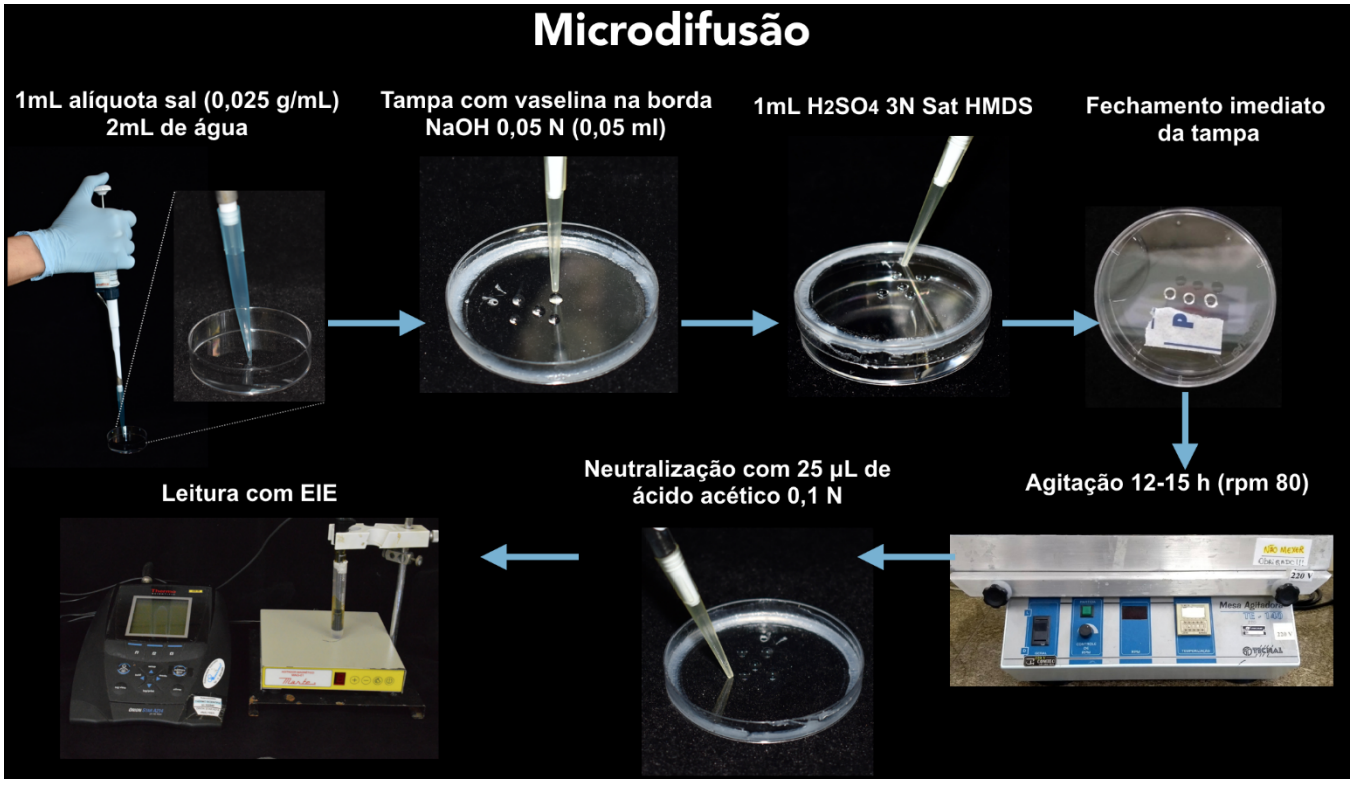
Apêndice 2. Tipo de granulação das marcas de sal.



Apêndice 3. Fluxograma da análise de fluoreto no sal com eletrodo íon específico (EIE) pelo método direto.

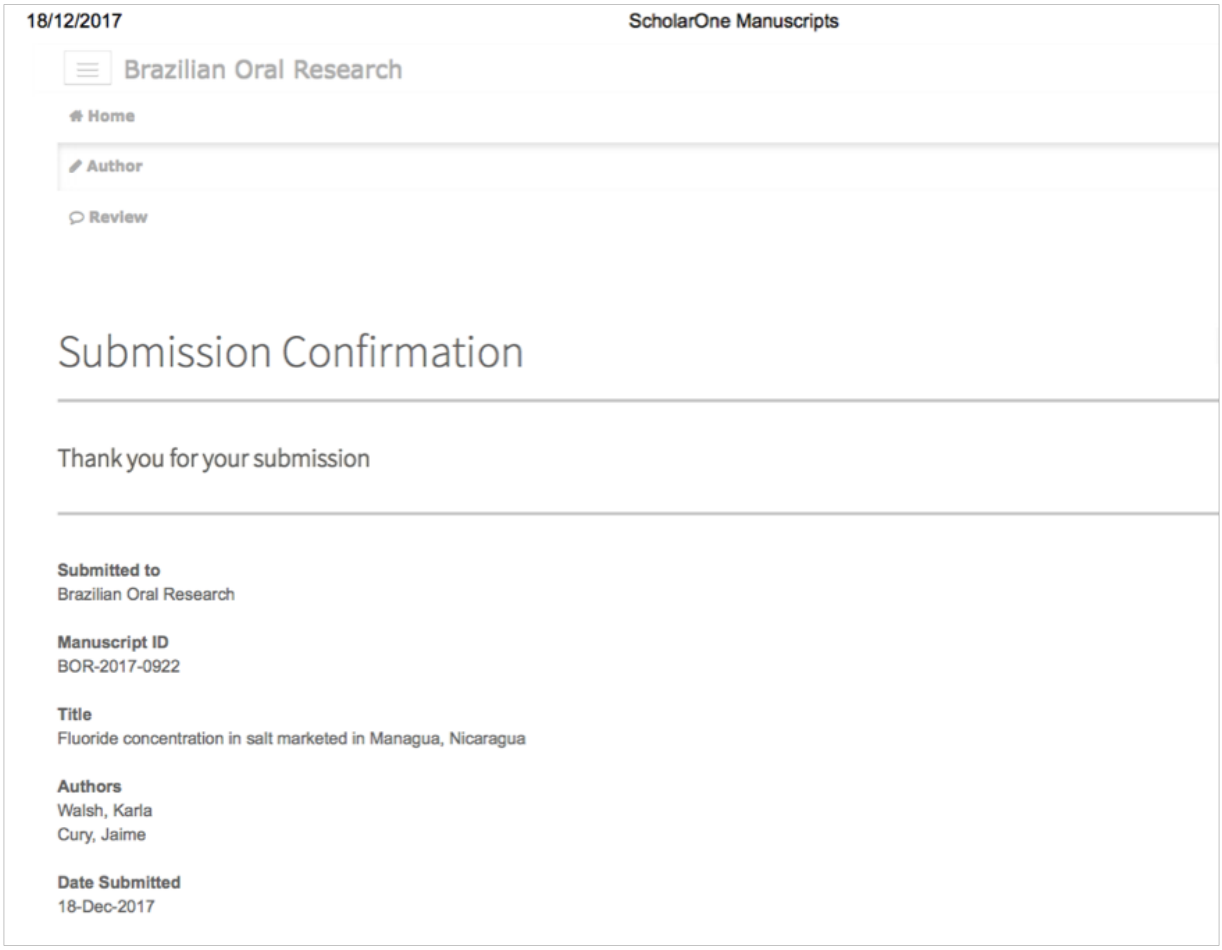


Apêndice 4. Fluxograma da análise de fluoreto no sal com eletrodo íon específico (EIE) depois de microdifusão.



ANEXOS

Comprovante da submissão do artigo.



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